



EDGEWOOD

CHEMICAL BIOLOGICAL CENTER

U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND

ECBC-TR-006

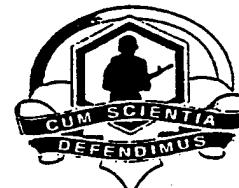
DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND
SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING
OF RESPONDER CSM LEVEL A GASTIGHT PROTECTIVE SUIT
MODEL 50660

Robert S. Lindsay
John M. Baranowski
Janice B. Hannigan

ENGINEERING DIRECTORATE

February 1999

Approved for public release, distribution is unlimited.



Aberdeen Proving Ground, MD 21010-5424

19990408047

Disclaimer

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorizing documents.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	February 1999	Final; 98 Jan – 98 Mar
4. TITLE AND SUBTITLE Domestic Preparedness Program: Liquid Sulfur Mustard and Sarin Challenge/Vapor Penetration Swatch Testing of Responder CSM Level A Gastight Protective Suit Model 50660		5. FUNDING NUMBERS None
6. AUTHOR(S) Lindsay, Robert S.; Baranoski, John M.; and Hannigan, Janice B.		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) DIR, ECBC*, ATTN: AMSSB-REN-SO, APG, MD 21010-5424		8. PERFORMING ORGANIZATION REPORT NUMBER ECBC-TR-006
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) DIR, ECBC, ATTN: AMSSB-RTD-D, APG, MD 21010-5424		10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES *When this work was performed, the U.S. Army Edgewood Chemical Biological Center (ECBC) was known as the U.S. Army Edgewood Research, Development and Engineering Center (ERDEC).		
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE
13. ABSTRACT (Maximum 200 words) A Responder CSM Level A Gastight Protective Suit, Model 50660 (Kappler Safety Group, Guntersville, AL) had swatches taken from six sample positions. These swatches were tested against sulfur mustard and sarin in accordance with U.S. Army Edgewood Research, Development and Engineering Center's (ERDEC) modified static diffusion procedure, which was derived from draft Test Operations Procedure (TOP) 8-2-501.		
14. SUBJECT TERMS HD Swatch testing Chemical protective suits GB Permeation Testing		15. NUMBER OF PAGES 29
		16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED
		20. LIMITATION OF ABSTRACT UL

Blank

Preface

The work described in this report was authorized under the Expert Assistance (Personal Protective Equipment Evaluation) Program for the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)* Program Director for Domestic Preparedness. The work was started in January 1998 and completed in March 1998.

The use of either trade or manufacturers' names in this report does not constitute an official endorsement of any commercial products. This report may not be cited for purposes of advertisement.

This report has been approved for public release. Registered users should request additional copies from the Defense Technical Information Center; unregistered users should direct such requests to the National Technical Information Service.

Acknowledgments

The authors acknowledge Marcia A. Johnson for her work in preparing the data tables.

* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

Blank

CONTENTS

1.	INTRODUCTION.....	7
2.	MATERIALS AND METHODS.....	7
2.1	Suit Description.....	7
2.2	Swatch Preparation.....	7
2.3	Test Procedure.....	9
3.	RESULTS AND DISCUSSION.....	11
3.1	HD Results.....	11
3.2	GB Results.....	11
3.3	Material Thickness.....	12
APPENDIXES		
	A-MODIFIED STATIC DIFFUSION PROCEDURE.....	13
	B-HD TABLES.....	15
	C-GB TABLES.....	23

FIGURES

1	Responder CSM Label.....	8
2	TOP Permeation Cell.....	9
3	Environmental Cabinet.....	10
4	MINICAMS and Stream Selection System.....	10

**DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND
SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING
OF RESPONDER CSM LEVEL A GASTIGHT PROTECTIVE SUIT
MODEL 50660**

1. INTRODUCTION

Under the Domestic Preparedness (DP) Expert Assistance [Personal Protective Equipment (PPE) Evaluation] Program, the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)* was tasked to perform testing of swatches taken from commercially-available Level A suits currently being used by emergency responders from cities involved in this program. The testing was performed by the Design Evaluation Group, Surety Team, Methodology, Instrumentation and Test Office, Engineering Directorate. The test procedure was jointly developed and agreed upon by ERDEC and the U. S. Army Natick, Research, Development and Engineering Center (NRDEC) (written communication, M. Chin, NRDEC, 1 May 97).

2. MATERIALS AND METHODS

2.1 Suit Description.

The Responder CSM suit ensemble consisted of the suit and a separate outer garment. The suit was manufactured by Kappler Safety Group (Guntersville, AL) and was blue in color. The suit ensemble model number was 50660, and the suit model number was 41660. Figure 1 is a digital photograph of the label found inside the suit.

2.2 Swatch Preparation.

The day before testing was scheduled to begin, the suit was picked up from Mask Issue and transported to the laboratory. The suit was folded up for transport and was hung on a hanger once in the laboratory. The suit was stored this way during and after testing. The outer garment was not to be tested and was stored elsewhere.

The swatch locations to be sampled were given in the PPE Test Team Work Contract for Level A Ensembles (written communication, R. Belmonte, Engineering Directorate, ERDEC, 25 June 1997). These swatch sampling locations were listed as suit material (SM), suit seam (SS), visor material (VM), zipper/suit material seam (ZP), glove (GL) and visor material/suit material seam (SV). The suit pass through could not be sampled because it could not be made flat to fit in a permeation cell. The swatches were normally cut the day before testing and conditioned overnight at the test conditions. For a Monday test, swatches were cut Friday and conditioned over the weekend. Normally, the swatches would be laid in the environmental cabinet for conditioning.

* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

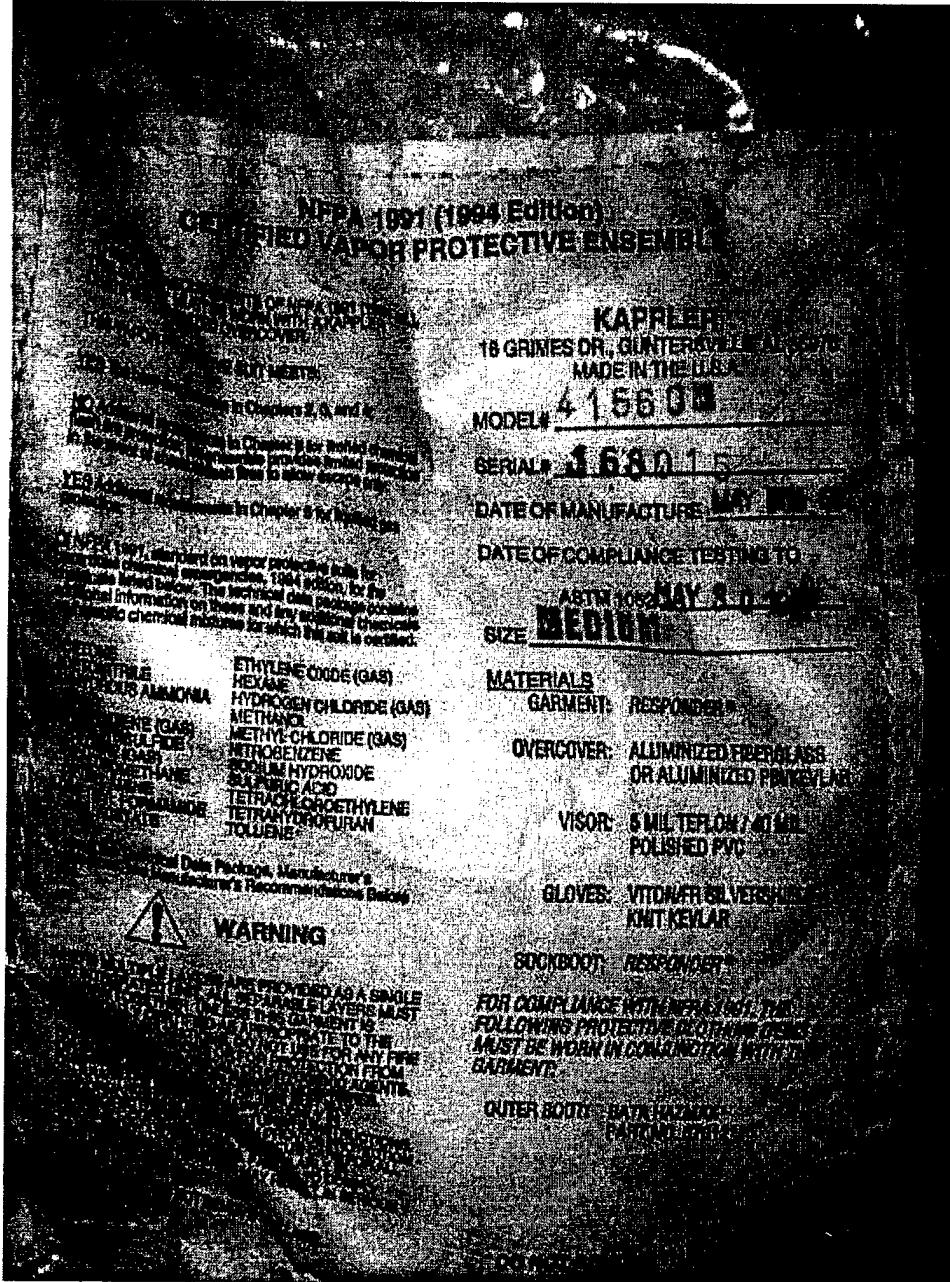


Figure 1. Responder CSM Label

The swatches were numbered in accordance with the PPE Test Team Work Instructions (written communication, R. Belmonte, Engineering Directorate, ERDEC, 11 June 1997); for example LC-KPL-SM-01, etc. All swatches were cut in triplicate, one at a time on a sample press. The swatch diameter was 2 in.

The reference material was 80-mil silicone, using the M45 mask formulation, prepared by Malcolm Little of the M45 mask team. Preparation and conditioning were the same as for the suit swatches.

2.3

Test Procedure.

The procedure agreed upon by ERDEC and NRDEC was derived from the report entitled, "Permeation and Penetration Testing of Air Permeable, Semi-permeable and Impermeable Materials with Chemical Agents or Simulants (Swatch Testing)" dated 3 March 1997. The Modified Static Diffusion Procedure is found in Appendix A of this report. Subsequent to the agreement, ERDEC personnel determined that the usage of the 80-mil silicone did not meet the definition of a positive control. The silicone swatches were used as an indication of agent vapor permeation. Equipment and schedule limitations prevented the use of negative controls. The terminology of the test procedure was not modified to reflect these changes.

The TOP permeation cell was used and a digital photograph of one is given as Figure 2.

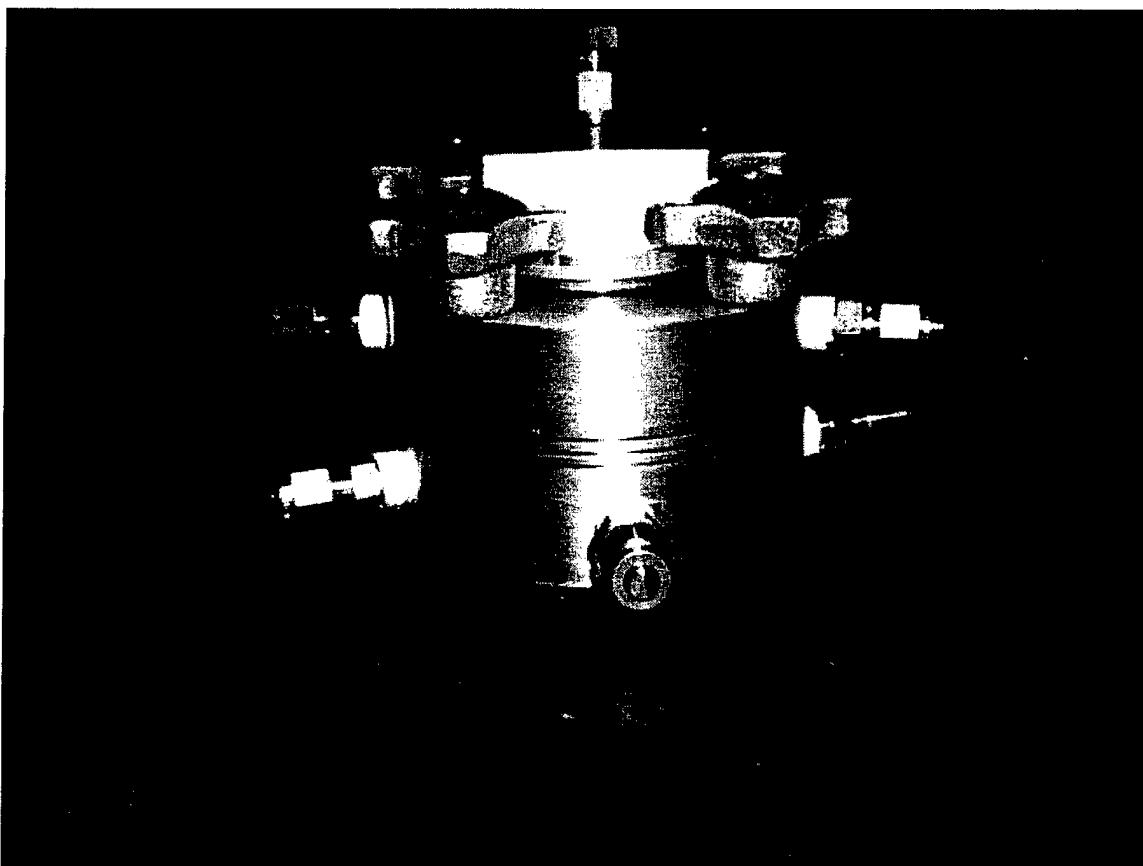


Figure 2. TOP Permeation Cell

The remainder of the test apparatus consisted of:

- Plastic environmental cabinet with sliding doors containing a permeation cell rack, circulating blower, and heat source (Figure 3).

- Flow/temperature/relative humidity control system; (Miller-Nelson Research Corporation, Monterey, CA) model HCS-410.
- Flow control system; (Tylan General Incorporated, Torrance, CA) Dynamass model FM-8.
- Mass flow controllers; (Tylan General Incorporated, Torrance, CA) model FC-260.
- Calibrated Vaisala humidity and temperature indicator.
- MINICAMS, serial number 2362, and Stream Selection System (CMS Research Corporation, Birmingham, AL), illustrated in Figure 4.

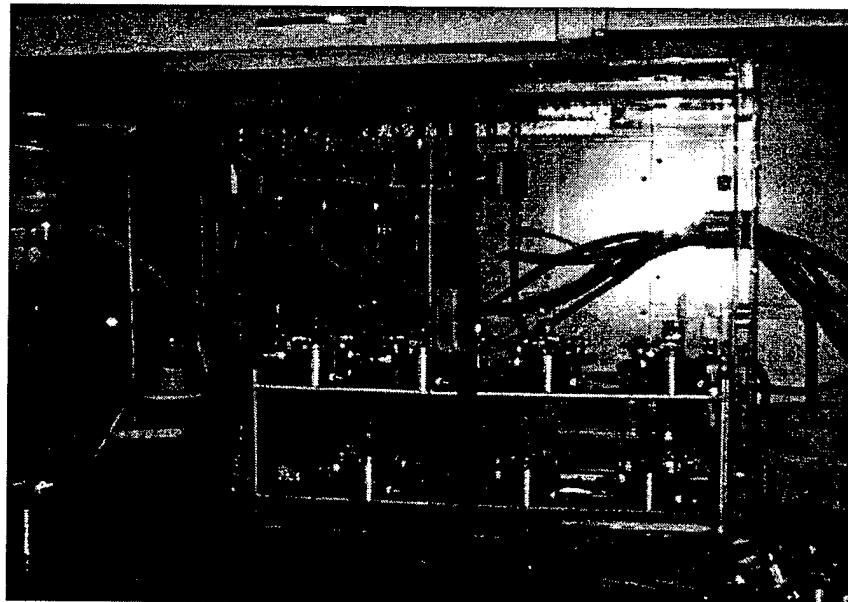


Figure 3. Environmental Cabinet

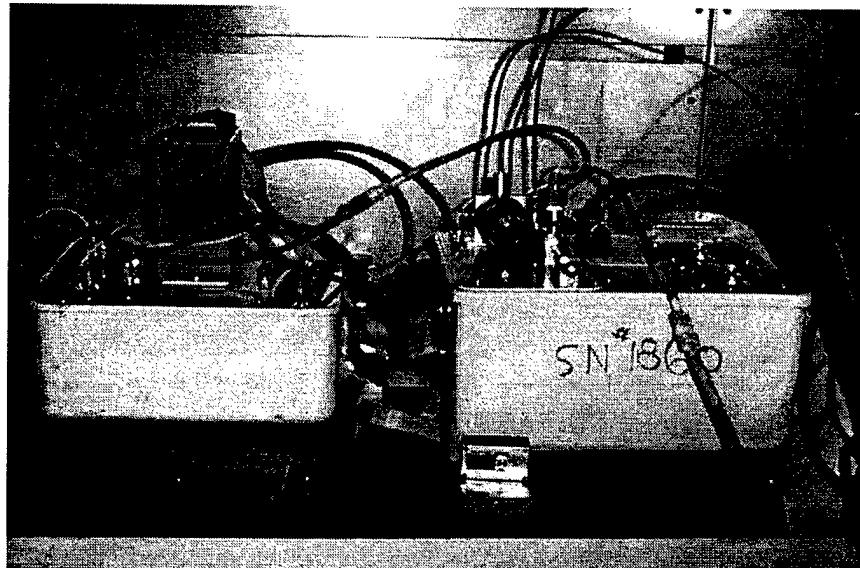


Figure 4. MINICAMS and Stream Selection System

3. RESULTS AND DISCUSSION

3.1 HD Results.

The HD permeation results are given in Appendix B as Tables B-1 through B-6. Average elapsed time was not used. The actual time that each swatch was sampled by the MINICAMS is shown.

The MINICAMS minimum detection limit was 1.0 ng for all test days. There were no visible effects on any of the materials from HD exposure. Cumulative permeation was highest for the zipper/material interface (over ten times higher than for the suit material).

The average temperature was 97.2 °F, and 17.6% RH was the average for all tests. Test temperatures were greater than 90 °F due to a malfunction in the laboratory heating system, which caused the room temperature to be elevated, and the lack of a cooling capability in the test apparatus. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used due to budget and schedule limitations.

3.2 GB Results.

The GB permeation results are given in Appendix C as Tables C-1 through C-6.

The MINICAMS minimum detection limit was 0.4 ng for all test days. There were no visible effects on any of the materials from GB exposure. Cumulative permeation was highest for the zipper/material interface (over ten times higher than for the suit material). Cumulative permeation was also elevated for the glove swatches and one suit/visor interface swatch when compared to the suit material.

The average temperature was 101.2 °F and 19.1% RH was the average for all tests. Test temperatures were greater than 90 °F due to a malfunction in the laboratory heating system, which caused the room temperature to be elevated, and the lack of a cooling capability in the test apparatus. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used.

Material Thickness.

After the HD and GB testing was completed, thickness measurements of the suit material, visor material, and glove material were made. A swatch of material was cut from the suit immediately adjacent to the area from which the agent swatches were taken. Twenty-four thickness measurements were taken on each swatch using an Ames dial comparator (B. C. Ames Company, Waltham, MA). The average thickness of the suit material swatch was 0.024 in.; the visor material swatch was 0.042 in.; and the glove swatch was 0.022 in.

APPENDIX A
MODIFIED STATIC DIFFUSION PROCEDURE

MODIFIED STATIC DIFFUSION TEST

This test procedure was adapted from the "Semipermeable and Impermeable Materials Static Diffusion Penetration Testing (Liquid Agent Challenge/Vapor Penetration; delta p = 0, Single Flow Test) given in Test Operations Procedure (TOP) 8-2-501 dated 3 Mar 97.

The following procedure will be used:

Upon receipt of a suit, all available information concerning the suit will be recorded; date of manufacture, lot number, serial number, materials of construction, etc.

From each suit, 3 ea 1 and 15/16 in. diameter material swatches will be taken for HD and a like number taken for GB. Depending upon the suit configuration, three seam swatches (same diameter) will be taken plus triplicate swatches of other flat components such as other seams, visor, gloves, booties, etc. for HD and an equal number for GB. Each swatch will be placed in an airtight bag and given a unique serial number which will be placed on the bag. A list of serial numbers will be kept with the swatches.

The environmental chamber will be controlled at a temperature of 90 +/- 2 °F, and the maximum achievable RH without occurrence of condensation (70% +/- 10% RH). The temperature and RH readings will be checked weekly with a calibrated meter. The test cell air will be drawn from the chamber air. There will be no system control and data acquisition system. The temperature and RH will be recorded in a computer file. Flow rates will be manually recorded. There will be no differential pressure monitoring since differential pressure gages of sufficient sensitivity are not available.

The TOP test cell will be used. When assembling, the cell lugs will be tightened by hand to finger tight. The flow rate beneath each swatch will be 1 L/min which will be controlled by a linear mass flow controller. The flows will be checked with a calibrated test meter weekly. Each test cell will be checked for leaks after assembly by connecting it to the vacuum source and checking that the inlet flow is the same as the outlet flow on the mass flow controller (cell lugs will be retightened if flows don't match).

The samples will serve as their own negative controls while being preconditioned overnight by being MINICAMS monitored. Eighty mil silicone will be used as a positive control for each test (six suit swatches and one silicone swatch).

Agents GB and HD will be used. The contamination density will be 10 g/m² (eight each 1 µl HD droplets or ten each 1 µl GB droplets). A robotic agent application system is not available. The agent will be applied using the click/touch method with a Hamilton repeating dispenser.

Seven swatches will be tested at once. MINICAMS with stream selection system will monitor vapor penetration with a 3-min cycle. There will be three blank sampling intervals following the control. Each swatch will be sampled once every 30 min. The MINICAMS will be standardized weekly.

The test length will be 24 hr.

The test cells and o-rings will be aerated between uses. No other cleaning method will be used.

The data to be reported are cumulative penetration (ng/cm²) versus average elapsed time (minutes) for each swatch. The average elapsed time is the sum of the elapsed time for swatch 1 and the elapsed time for swatch 6 divided by 2. All recorded data will be placed in laboratory notebooks and a technical report will be drafted at the conclusion of this effort.

For entry into the DP database, the data for each swatch will be reported as cumulative penetration for the first four sampling intervals (approximately 12, 42, 72, and 102 min), and at approximately 6, 12, 18, and 24 hr.

Appendix A

APPENDIX B
HD TABLES

Table B-1. Kappler 50660 Suit Material vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 23 Feb 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	0	34	0	37	0
61	0	64	0	67	0
91	0	94	0	97	0
121	0	124	0	127	0
151	3	154	0	157	0
181	8	184	3	187	0
211	15	214	8	217	2
241	23	244	14	247	7
271	30	274	20	277	12
301	38	304	26	307	15
331	45	334	32	337	17
361	53	364	38	367	20
391	60	394	43	397	20
421	67	424	49	427	20
451	73	454	55	457	20
481	80	484	60	487	20
511	86	514	65	517	20
541	92	544	68	547	20
571	98	574	68	577	20
601	104	604	68	607	20
631	109	634	68	637	20
661	115	664	68	667	20
691	120	694	68	697	20
721	125	724	68	727	20
751	127	754	68	757	20
781	127	784	68	787	20
811	127	814	68	817	20
841	127	844	68	847	20
871	127	874	68	877	20
901	127	904	68	907	20
931	127	934	68	937	20
961	127	964	68	967	20
991	127	994	68	997	20
1021	127	1024	68	1027	20
1051	127	1054	68	1057	20
1081	127	1084	68	1087	20
1111	127	1114	68	1117	20
1141	127	1144	68	1147	20
1171	127	1174	68	1177	20
1201	127	1204	68	1207	20
1231	127	1234	68	1237	20
1261	127	1264	68	1267	20
1291	127	1294	68	1297	20
1321	127	1324	68	1327	20
1351	127	1354	68	1357	20
1381	127	1384	68	1387	20
1411	127	1414	68	1417	20

Table B-2. Kappler 50660 Suit Seam vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 23 Feb 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	0
40	0	43	0	46	0
70	0	73	0	76	0
100	0	103	0	106	0
130	0	133	0	136	0
160	0	163	0	166	0
190	0	193	0	196	0
220	0	223	0	226	0
250	0	253	0	256	0
280	0	283	0	286	0
310	0	313	0	316	0
340	0	343	0	346	0
370	0	373	0	376	0
400	0	403	0	406	0
430	0	433	0	436	0
460	0	463	0	466	0
490	0	493	0	496	0
520	0	523	0	526	0
550	0	553	0	556	0
580	0	583	0	586	0
610	0	613	0	616	0
640	0	643	0	646	0
670	0	673	0	676	0
700	0	703	0	706	0
730	0	733	0	736	0
760	0	763	0	766	0
790	0	793	0	796	0
820	0	823	0	826	0
850	0	853	0	856	0
880	0	883	0	886	0
910	0	913	0	916	0
940	0	943	0	946	0
970	0	973	0	976	0
1000	0	1003	0	1006	0
1030	0	1033	0	1036	0
1060	0	1063	0	1066	0
1090	0	1093	0	1096	0
1120	0	1123	0	1126	0
1150	0	1153	0	1156	0
1180	0	1183	0	1186	0
1210	0	1213	0	1216	0
1240	0	1243	0	1246	0
1270	0	1273	0	1276	0
1300	0	1303	0	1306	0
1330	0	1333	0	1336	0
1360	0	1363	0	1366	0
1390	0	1393	0	1396	0
1420	0	1423	0	1426	0

Appendix B

Table B-3. Kappler 50660 Glove vs. HD Liquid, 10 g/m²
 Modified Static Diffusion Test, 25 Feb 98
 Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	0	34	0	37	0
61	0	64	0	67	0
91	0	94	0	97	0
121	0	124	0	127	0
151	3	154	0	157	0
181	11	184	3	187	0
211	20	214	10	217	3
241	30	244	17	247	9
271	41	274	25	277	15
301	52	304	34	307	22
331	63	334	42	337	28
361	75	364	51	367	35
391	86	394	59	397	42
421	98	424	68	427	49
451	109	454	77	457	56
481	120	484	85	487	63
511	131	514	94	517	70
541	142	544	102	547	77
571	153	574	110	577	83
601	163	604	119	607	90
631	174	634	127	637	96
661	184	664	135	667	103
691	194	694	142	697	109
721	204	724	150	727	115
751	213	754	158	757	121
781	223	784	165	787	127
811	232	814	173	817	134
841	241	844	180	847	139
871	250	874	187	877	145
901	259	904	194	907	151
931	268	934	201	937	157
961	276	964	208	967	162
991	285	994	214	997	168
1021	293	1024	221	1027	174
1051	301	1054	228	1057	179
1081	309	1084	234	1087	184
1111	317	1114	241	1117	190
1141	325	1144	247	1147	195
1171	333	1174	254	1177	201
1201	341	1204	260	1207	206
1231	350	1234	267	1237	212
1261	358	1264	274	1267	218
1291	367	1294	281	1297	223
1321	376	1324	288	1327	229
1351	384	1354	295	1357	235
1381	393	1384	302	1387	241
1411	401	1414	309	1417	247

Table B-4. Kappler 50660 Zipper Material/Interface vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 25 Feb 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	0
40	7	43	0	46	0
70	13	73	0	76	0
100	13	103	0	106	0
130	18	133	3	136	0
160	38	163	15	166	5
190	98	193	56	196	24
220	207	223	144	226	70
250	363	253	274	256	154
280	570	283	447	286	268
310	839	313	672	316	408
340	1179	343	958	346	573
370	1597	373	1311	376	764
400	2090	403	1732	406	983
430	2654	433	2225	436	1233
460	3287	463	2784	466	1507
490	3987	493	3416	496	1807
520	4745	523	4114	526	2134
550	5553	553	4854	556	2482
580	6392	583	5637	586	2852
610	7251	613	6454	616	3243
640	8125	643	7299	646	3654
670	9007	673	8181	676	4079
700	9921	703	9103	706	4520
730	10857	733	10058	736	4980
760	11790	763	11025	766	5452
790	12719	793	11996	796	5935
820	13647	823	12977	826	6430
850	14565	853	13990	856	6943
880	15475	883	15020	886	7472
910	16382	913	16049	916	8005
940	17274	943	17095	946	8544
970	18152	973	18137	976	9089
1000	19004	1003	19156	1006	9641
1030	19824	1033	20166	1036	10196
1060	20628	1063	21167	1066	10754
1090	21416	1093	22160	1096	11323
1120	22196	1123	23171	1126	11900
1150	22980	1153	24194	1156	12495
1180	23771	1183	25238	1186	13113
1210	24572	1213	26308	1216	13761
1240	25400	1243	27409	1246	14464
1270	26267	1273	28564	1276	15213
1300	27134	1303	29735	1306	15977
1330	27991	1333	30893	1336	16739
1360	28852	1363	32040	1366	17520
1390	29711	1393	33176	1396	18313
1420	30581	1423	34339	1426	19147

Table B-5. Kappler 50660 Visor Material vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 24 Feb 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	0	34	0	37	0
61	0	64	0	67	0
91	0	94	0	97	0
121	0	124	0	127	0
151	0	154	0	157	0
181	3	184	0	187	0
211	9	214	2	217	0
241	16	244	7	247	0
271	22	274	12	277	0
301	29	304	18	307	0
331	35	334	23	337	0
361	42	364	25	367	0
391	48	394	25	397	0
421	54	424	25	427	0
451	59	454	25	457	0
481	65	484	25	487	0
511	70	514	25	517	0
541	75	544	25	547	0
571	80	574	25	577	0
601	85	604	25	607	0
631	88	634	25	637	0
661	88	664	25	667	0
691	88	694	25	697	0
721	88	724	25	727	0
751	88	754	25	757	0
781	88	784	25	787	0
811	88	814	25	817	0
841	88	844	25	847	0
871	88	874	25	877	0
901	88	904	25	907	0
931	88	934	25	937	0
961	88	964	25	967	0
991	88	994	25	997	0
1021	88	1024	25	1027	0
1051	88	1054	25	1057	0
1081	88	1084	25	1087	0
1111	88	1114	25	1117	0
1141	88	1144	25	1147	0
1171	88	1174	25	1177	0
1201	88	1204	25	1207	0
1231	88	1234	25	1237	0
1261	88	1264	25	1267	0
1291	88	1294	25	1297	0
1321	88	1324	25	1327	0
1351	88	1354	25	1357	0
1381	88	1384	25	1387	0
1411	88	1414	25	1417	0

Table B-6. Kappler 50660 Suit/Visor Interface vs HD Liquid, 10 g/m²
Modified Static Diffusion Test, 24 Feb 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	0
40	0	43	0	46	0
70	0	73	0	76	0
100	0	103	0	106	0
130	0	133	0	136	0
160	0	163	0	166	0
190	0	193	0	196	0
220	0	223	0	226	0
250	0	253	0	256	0
280	0	283	0	286	0
310	0	313	0	316	0
340	0	343	0	346	0
370	0	373	0	376	0
400	0	403	0	406	0
430	0	433	0	436	0
460	0	463	0	466	0
490	0	493	0	496	0
520	0	523	0	526	0
550	0	553	0	556	0
580	0	583	0	586	0
610	0	613	0	616	0
640	0	643	0	646	0
670	0	673	0	676	0
700	0	703	0	706	0
730	0	733	0	736	0
760	0	763	0	766	0
790	0	793	0	796	0
820	0	823	0	826	0
850	0	853	0	856	0
880	0	883	0	886	0
910	0	913	0	916	0
940	0	943	0	946	0
970	0	973	0	976	0
1000	0	1003	0	1006	0
1030	0	1033	0	1036	0
1060	0	1063	0	1066	0
1090	0	1093	0	1096	0
1120	0	1123	0	1126	0
1150	0	1153	0	1156	0
1180	0	1183	0	1186	0
1210	0	1213	0	1216	0
1240	0	1243	0	1246	0
1270	0	1273	0	1276	0
1300	0	1303	0	1306	0
1330	0	1333	0	1336	0
1360	0	1363	0	1366	0
1390	0	1393	0	1396	0
1420	0	1423	0	1426	0

Blank

APPENDIX C
GB TABLES

Table C-1. Kappler 50660 Suit Material vs. GB Liquid, 10 g/m²
Modified Static Diffusion Test, 12 Feb 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	1
31	6	34	5	37	4
61	8	64	7	67	4
91	8	94	7	97	4
121	8	124	7	127	4
151	8	154	7	157	4
181	8	184	7	187	4
211	8	214	7	217	4
241	8	244	7	247	4
271	8	274	7	277	4
301	8	304	7	307	4
331	8	334	7	337	4
361	8	364	7	367	4
391	8	394	7	397	4
421	8	424	7	427	4
451	8	454	7	457	4
481	8	484	7	487	4
511	8	514	7	517	4
541	8	544	7	547	4
571	8	574	7	577	4
601	8	604	7	607	4
631	8	634	7	637	4
661	8	664	7	667	4
691	8	694	7	697	4
721	8	724	7	727	4
751	8	754	7	757	4
781	8	784	7	787	4
811	8	814	7	817	4
841	8	844	7	847	4
871	8	874	7	877	4
901	8	904	7	907	4
931	8	934	7	937	4
961	8	964	7	967	4
991	8	994	7	997	4
1021	8	1024	7	1027	4
1051	8	1054	7	1057	4
1081	8	1084	7	1087	4
1111	8	1114	7	1117	4
1141	8	1144	7	1147	4
1171	8	1174	7	1177	4
1201	8	1204	7	1207	4
1231	8	1234	7	1237	4
1261	8	1264	7	1267	4
1291	8	1294	7	1297	4
1321	8	1324	7	1327	4
1351	8	1354	7	1357	4
1381	8	1384	7	1387	4
1411	8	1414	7	1417	4

Appendix C

Table C-2. Kappler 50660 Suit Seam vs. GB Liquid, 10 g/m²
Modified Static Diffusion Test, 12 Feb 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	1	13	0	16	2
40	4	43	0	46	4
70	4	73	0	76	4
100	4	103	0	106	4
130	4	133	0	136	4
160	4	163	0	166	4
190	4	193	0	196	4
220	4	223	0	226	4
250	4	253	0	256	4
280	4	283	0	286	4
310	4	313	0	316	4
340	4	343	0	346	4
370	4	373	0	376	4
400	4	403	0	406	4
430	4	433	0	436	4
460	4	463	0	466	4
490	4	493	0	496	4
520	4	523	0	526	4
550	4	553	0	556	4
580	4	583	0	586	4
610	4	613	0	616	4
640	4	643	0	646	4
670	4	673	0	676	4
700	4	703	0	706	4
730	4	733	0	736	4
760	4	763	0	766	4
790	4	793	0	796	4
820	4	823	0	826	4
850	4	853	0	856	4
880	4	883	0	886	4
910	4	913	0	916	4
940	4	943	0	946	4
970	4	973	0	976	4
1000	4	1003	0	1006	4
1030	4	1033	0	1036	4
1060	4	1063	0	1066	4
1090	4	1093	0	1096	4
1120	4	1123	0	1126	4
1150	4	1153	0	1156	4
1180	4	1183	0	1186	4
1210	4	1213	0	1216	4
1240	4	1243	0	1246	4
1270	4	1273	0	1276	4
1300	4	1303	0	1306	4
1330	4	1333	0	1336	4
1360	4	1363	0	1366	4
1390	4	1393	0	1396	4
1420	4	1423	0	1426	4

Table C-3. Kappler 50660 Glove vs. GB Liquid, 10 g/m²
 Modified Static Diffusion Test, 18 Feb 98
 Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	2	13	2	16	3
40	8	43	9	46	10
70	12	73	14	76	14
100	17	103	16	106	17
130	25	133	16	136	17
160	44	163	18	166	17
190	78	193	24	196	17
220	131	223	31	226	19
250	199	253	39	256	23
280	278	283	50	286	29
310	366	313	61	316	35
340	460	343	74	346	41
370	552	373	86	376	47
400	641	403	97	406	53
430	729	433	109	436	59
460	813	463	120	466	65
490	895	493	131	496	71
520	974	523	142	526	77
550	1050	553	152	556	82
580	1122	583	162	586	88
610	1190	613	172	616	93
640	1257	643	181	646	98
670	1320	673	190	676	103
700	1381	703	199	706	107
730	1440	733	207	736	112
760	1497	763	216	766	116
790	1551	793	224	796	120
820	1603	823	231	826	125
850	1653	853	238	856	129
880	1701	883	245	886	133
910	1747	913	252	916	136
940	1790	943	258	946	140
970	1831	973	265	976	142
1000	1871	1003	270	1006	142
1030	1909	1033	276	1036	142
1060	1945	1063	282	1066	142
1090	1980	1093	288	1096	142
1120	2015	1123	293	1126	142
1150	2050	1153	298	1156	142
1180	2082	1183	303	1186	142
1210	2112	1213	308	1216	142
1240	2142	1243	313	1246	142
1270	2172	1273	318	1276	142
1300	2201	1303	323	1306	142
1330	2229	1333	328	1336	142
1360	2257	1363	333	1366	142
1390	2285	1393	337	1396	142
1420	2313	1423	342	1426	142

Appendix C

Table C-4. Kappler 50660 Zipper Material/Interface vs. GB Liquid, 10 g/m²
Modified Static Diffusion Test, 18 Feb 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	1	7	1
31	40	34	7	37	6
61	85	64	13	67	10
91	117	94	27	97	50
121	243	124	86	127	227
151	521	154	241	157	625
181	970	184	501	187	1268
211	1598	214	835	217	2142
241	2373	244	1236	247	3204
271	3252	274	1701	277	4367
301	4196	304	2216	307	5542
331	5165	334	2765	337	6708
361	6136	364	3326	367	7872
391	7100	394	3881	397	9032
421	8041	424	4424	427	10191
451	8953	454	4959	457	11350
481	9849	484	5483	487	12509
511	10727	514	5991	517	13656
541	11581	544	6484	547	14784
571	12403	574	6968	577	15882
601	13187	604	7445	607	16936
631	13952	634	7909	637	17954
661	14701	664	8358	667	18947
691	15423	694	8796	697	19920
721	16116	724	9224	727	20864
751	16783	754	9641	757	21769
781	17436	784	10051	787	22641
811	18065	814	10449	817	23484
841	18663	844	10832	847	24294
871	19244	874	11204	877	25076
901	19807	904	11566	907	25831
931	20351	934	11919	937	26560
961	20877	964	12263	967	27264
991	21387	994	12603	997	27947
1021	21882	1024	12939	1027	28615
1051	22364	1054	13273	1057	29271
1081	22836	1084	13603	1087	29909
1111	23302	1114	13931	1117	30529
1141	23757	1144	14256	1147	31138
1171	24198	1174	14580	1177	31735
1201	24625	1204	14900	1207	32314
1231	25043	1234	15221	1237	32876
1261	25459	1264	15543	1267	33431
1291	25875	1294	15862	1297	33977
1321	26286	1324	16182	1327	34516
1351	26690	1354	16499	1357	35050
1381	27086	1384	16816	1387	35578
1411	27476	1414	17134	1417	36102

Appendix C

Table C-5. Kappler 50660 Visor Material vs. GB Liquid, 10 g/m²
 Modified Static Diffusion Test, 19 Feb 98
 Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	1
31	6	34	5	37	6
61	8	64	7	67	11
91	8	94	7	97	12
121	8	124	7	127	12
151	8	154	7	157	12
181	8	184	7	187	12
211	8	214	7	217	12
241	8	244	7	247	12
271	8	274	7	277	12
301	8	304	7	307	12
331	8	334	7	337	12
361	8	364	7	367	12
391	8	394	7	397	12
421	8	424	7	427	12
451	8	454	7	457	12
481	8	484	7	487	12
511	8	514	7	517	12
541	8	544	7	547	12
571	8	574	7	577	12
601	8	604	7	607	12
631	8	634	7	637	12
661	8	664	7	667	12
691	8	694	7	697	12
721	8	724	7	727	12
751	8	754	7	757	12
781	8	784	7	787	12
811	8	814	7	817	12
841	8	844	7	847	12
871	8	874	7	877	12
901	8	904	7	907	12
931	8	934	7	937	12
961	8	964	7	967	12
991	8	994	7	997	12
1021	8	1024	7	1027	12
1051	8	1054	7	1057	12
1081	8	1084	7	1087	12
1111	8	1114	7	1117	12
1141	8	1144	7	1147	12
1171	8	1174	7	1177	12
1201	8	1204	7	1207	12
1231	8	1234	7	1237	12
1261	8	1264	7	1267	12
1291	8	1294	7	1297	12
1321	8	1324	7	1327	12
1351	8	1354	7	1357	12
1381	8	1384	7	1387	12
1411	8	1414	7	1417	12

Table C-6. Kappler 50660 Suit/Visor Interface vs. GB Liquid, 10 g/m²
 Modified Static Diffusion Test, 19 Feb 98
 Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	2	10	2	16	2
40	9	40	9	46	6
70	11	70	11	76	14
100	11	100	11	106	62
130	11	130	11	136	166
160	11	160	11	166	300
190	11	190	11	196	446
220	11	220	11	226	592
250	11	250	11	256	735
280	11	280	11	286	872
310	11	310	11	316	1004
340	11	340	11	346	1130
370	11	370	11	376	1252
400	11	400	11	406	1369
430	11	430	11	436	1481
460	11	460	11	466	1589
490	11	490	11	496	1694
520	11	520	11	526	1794
550	11	550	11	556	1889
580	11	580	11	586	1981
610	11	610	11	616	2069
640	11	640	11	646	2155
670	11	670	11	676	2238
700	11	700	11	706	2316
730	11	730	11	736	2394
760	11	760	11	766	2471
790	11	790	11	796	2546
820	11	820	11	826	2619
850	11	850	11	856	2690
880	11	880	11	886	2757
910	11	910	11	916	2824
940	11	940	11	946	2891
970	11	970	11	976	2958
1000	11	1000	11	1006	3024
1030	11	1030	11	1036	3090
1060	11	1060	11	1066	3154
1090	11	1090	11	1096	3216
1120	11	1120	11	1126	3277
1150	11	1150	11	1156	3336
1180	11	1180	11	1186	3395
1210	11	1210	11	1216	3455
1240	11	1240	11	1246	3514
1270	11	1270	11	1276	3571
1300	11	1300	11	1306	3629
1330	11	1330	11	1336	3686
1360	11	1360	11	1366	3741
1390	11	1390	11	1396	3795
1420	11	1420	11	1426	3849

Appendix C